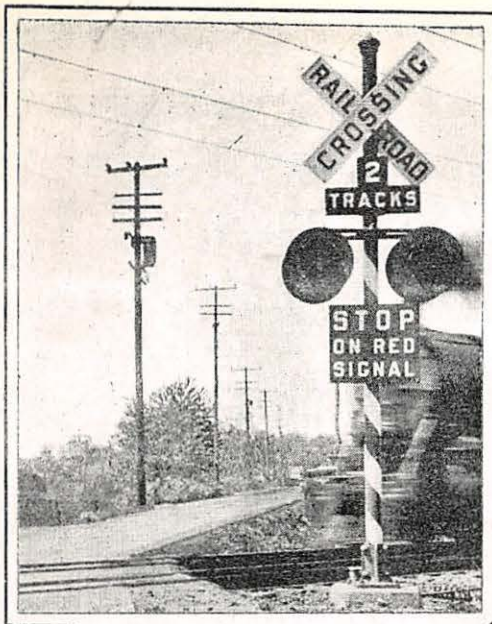
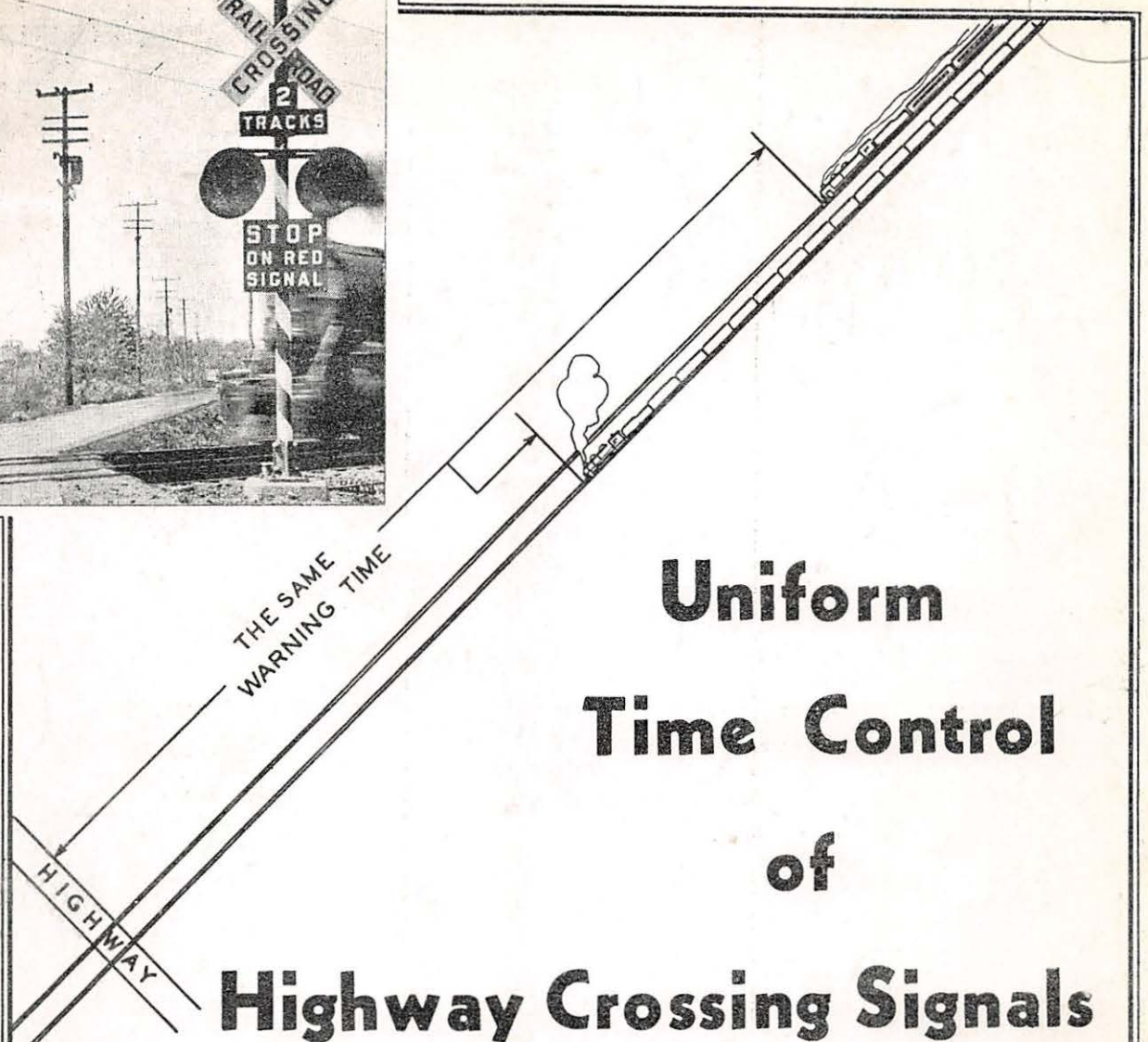
AWF





Uniform Time Control of Highway Crossing Signals

U.D.216

UNION SWITCH & SIGNAL CO.
SWISSVALE » « PENNSYLVANIA

Union Switch & Signal Co.
SWISSVALE, PA.

Subject: Highway Crossing Signals
Uniform Time Control

Union Development
Number 216
Date Jan. 30, 1936
13 Sheets

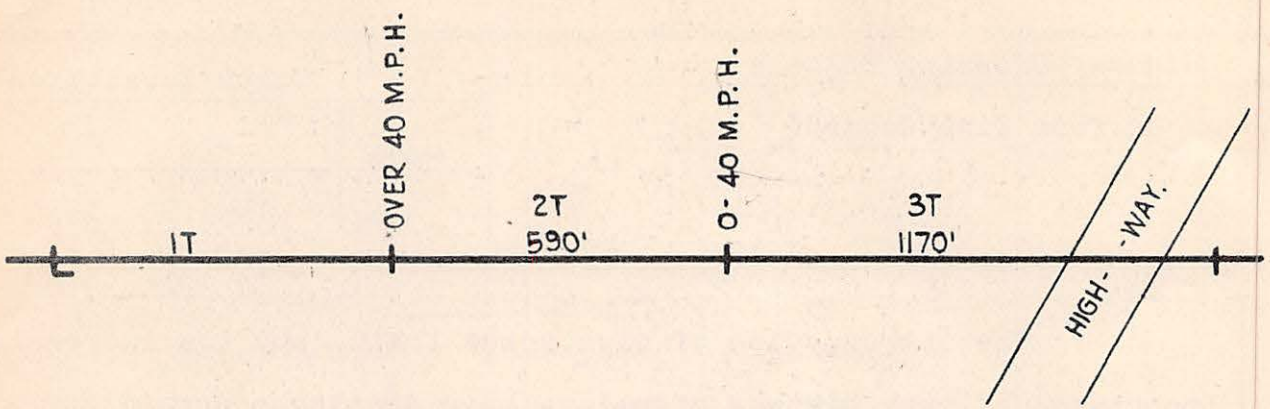
The introduction of high speed trains and the increasing importance of many highway crossings have created a demand for more uniform time control of highway crossing signals.

It is first necessary to measure the speed of each train before the train passes the point which would permit the minimum warning time at maximum speed. This can best be accomplished by a track circuit arranged to operate a timing device. Having determined the speed of a train we can then provide automatic means for starting the operation of the crossing signal when the train advances to a point which will produce a satisfactory warning.

Track Circuit Arrangement

Let us first consider a crossing where the maximum train speed is 60 m.p.h. and most trains move at fairly uniform speed and practically all trains maintain a speed of more than 25 m.p.h.

The layout shown in Fig. 1 would then provide a warning time of 20 to 30 seconds. Section 1T is a timing section arranged to operate a time element relay. The length of section 1T and the pick-up time of the time element relay are so proportioned that with a train moving at less than 40 m.p.h. the time element relay will close its front contacts and complete circuits which will delay



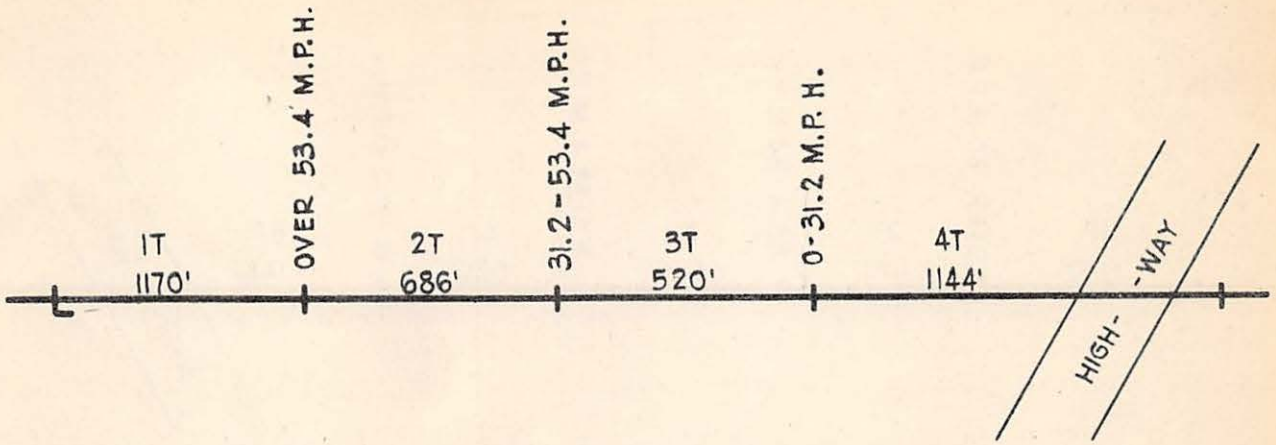
SPEED M.P.H.	WARNING TIME - SEC.
60	20
50	24.1
40 +	30
40 -	20
30	26.6
25	32
20	40
10	80

Fig. 1

the operation of the crossing signal until the train enters section 3T. A train moving faster than 40 m.p.h. will enter section 2T before the time element relay closes its front contacts with the result that the crossing signal starts operating with the train at this point.

A table in Fig. 1 gives the warning time for trains of various speeds in the assumed layout. It is evident that the length of the track sections can be modified to a certain extent to meet various conditions.

Now, if we have a higher maximum train speed, say 80 m.p.h., we may consider the layout shown in Fig.2. The arrangements provide



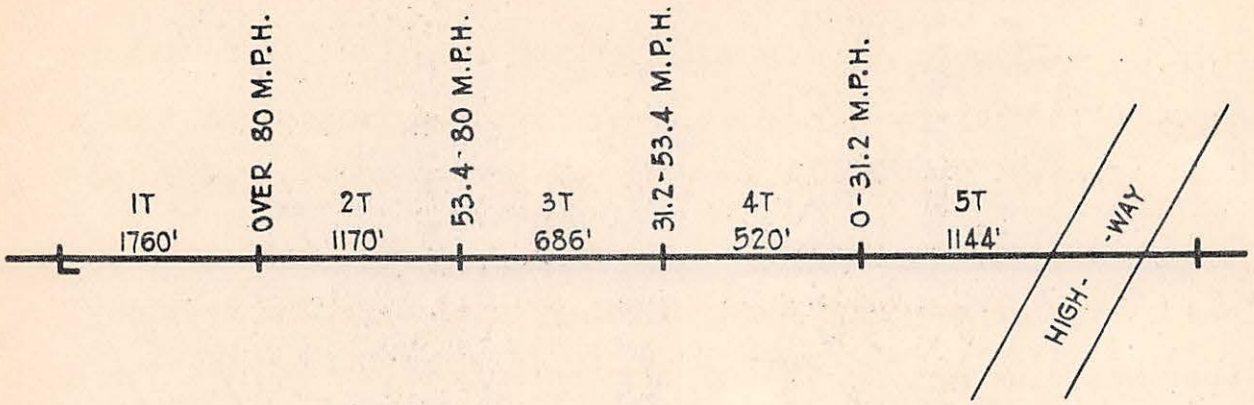
SPEED M.P.H.	WARNING TIME-SEC.
80	20
70	22.8
60	26.6
53.4+	30
53.4-	20
50	21.4
40	26.7
31.2+	36
31.2-	25
25	31.3

Fig. 2

two operations of the time element relay. The first to differentiate high and medium speed trains and the second to differentiate medium and low speed trains.

Section 1T is the first timing section. The time element relay in this case is adjusted for 15 seconds operation. Then trains moving at more than 53.4 m.p.h. will enter section 2T before the time element relay closes its front contacts and will start the operation of the crossing signal at that point.

Trains moving at less than 53.4 m.p.h. will establish a



SPEED M.P.H.	WARNING TIME-SEC.
120	20
110	21.8
100	24
90	26.7
80+	30
80-	20
70	22.8
60	26.6
53.4+	30
53.4-	20
50	21.4
40	26.7
31.2+	36
31.2-	25
25	31.3

Fig. 3

cut-out circuit around section 2T and cause the time element relay to release and start a second operation. The second section 2T is proportionally shorter than section 1T. Then trains moving at more than 31.2 m.p.h., will enter section 3T before the second operation of the time element relay is completed and will operate the crossing signal while in sections 3T and 4T.

It is then evident that trains moving at less than 31.2 m.p.h., will only operate the crossing signal while in section 4T.

Still higher speed trains must be considered. So we have provided Fig. 3 showing an extension of the system described in Fig. 2 to include one more track section. This involves three operations of the time element relay, upon entering section 1T, upon entering section 2T and upon entering section 3T. The maximum speed shown in this diagram is 120 m.p.h. and the warning times are shown for various speeds in the table.

Should it be necessary to consider trains of lower speeds than provided for in Figs. 2 and 3, the entire layout of distances can be rearranged or another cut section can be added nearer the crossing and the time element relay operated once more.

An infinite number of combinations of speeds, times and distances may be used. When advised the maximum and minimum speed of trains and the permissible variation in warning time, we can determine the layout of track circuits required. The location of automatic block signals should also be furnished because it may often be possible to design the system so as to employ the same cut sections for control of the crossing signal and for control of the automatic block signals.

Station Stops and Switching

A station may be located within the limits of any section except the one next to the crossing without causing undue operation of the crossing signal. A study of typical braking curves shows that, if a train stops in one of these sections, it will have consumed sufficient time in each of the preceding sections for the

time element to complete its operation. Should a station be located nearer the crossing, some other means can be provided to prevent unnecessary operation.

Special means can also be provided to insure operation of the time element and time control of the signal when a switch is located in one of the approach sections.

Track Circuit Failure:

The circuits presented have been designed to minimize the effects of track circuit failure. It will be noted that each section cut out by the time element is relatively short and that in each case a track section is provided which will operate the crossing signals regardless of the speed of trains.

Where automatic block signals are used, a track circuit failure would affect the automatic block signals at the same time which would cause trains to move slowly through the territory so that the shorter approach would provide ample warning time.

Acceleration:

The problem of train acceleration will, no doubt, enter into the consideration of the track circuit arrangement for any particular location and an analysis should be made on the basis of traffic conditions. Track section lengths used in this description are based on fairly uniform train speeds. Calculations show that trains accelerating above certain rates may reduce the warning time slightly under the 20 second minimum. If it is desired to provide for acceleration, we would suggest that a minimum warning time of about 25 seconds be used for normal train movements.

Circuits TM6A7 and TM6A8:

The track circuit arrangement shown on drawing TM6A7 provides for one timing section on each track of a double track crossing and two approach sections on each track. There are, no doubt, many crossings where time control would be desired mainly as a means for providing a 20 to 30 second warning for trains moving from say 40 to 60 m.p.h. and at the same time not operate the crossing signals too long for trains of 20 to 40 m.p.h.

Assuming an eastbound train approaching from the left at less than 40 m.p.h. The time required for this train to travel the length of section 1T would be more than the pick-up time of time element relay ETER.

This eastbound train entering section 1T shunts relay 1TR. A back contact of relay 1TR closes the pick-up circuit of relay ESR which continues through front contacts on track relays 2TR and 3TR and the checking contact of time element relay ETER to relay ESR. Relay ESR picks up and closes a shunt around the checking contact of relay ETER. The operating circuit of relay ETER is closed at another front contact of relay ESR.

Relay EXR operates the crossing signals for eastbound moves. The normal circuit of relay EXR is over front contacts of track relays 2TR and 3TR. When time element relay ETER completes its pick-up, by the circuit mentioned above, it closes an auxiliary circuit for relay EXR, which includes front contacts on relays ETER, ESR and 3TR. Now, when the train enters section 2T and shunts relay 2TR, the pick-up circuit traced for relay ESR and the first circuit traced for relay EXR will be opened. A holding circuit is closed

for relay ESR on account of relay ETER being picked up. This circuit is from B through front contacts on relays ETER and ESR, a back contact on relay 2TR and front contacts on relays 3TR and ESR to the coil of relay ESR which retains relay ESR until the train enters section 3T.

The shunting of relay 3TR as the train advances opens the circuits of relays EXR and ESR which operate the crossing signal and release the time element relay respectively.

It will then be noted that a train moving at less than 40 m.p.h. starts the operation of the crossing signal upon entering section 3T.

Now the length of section 1T and the setting of time element relay ETER are so proportioned that a train moving at more than 40 m.p.h. will travel the length of section 1T in less than the time required to close the front contacts of relay ETER. Then. with track relay 2TR shunted, the auxiliary circuit traced for EXR and the holding circuit for relay ESR, mentioned above, are open and the crossing signal starts operating at once.

Then, for trains of over 40 m.p.h., the crossing signal is operated while both sections 2T and 3T are occupied which provides a proportionally longer approach section to compensate for the greater speed.

A train may enter sections 1T and 2T to do switching and then back out without operating the crossing signal. Also, a train making a station stop in these sections would not operate the crossing signal.

The length of the sections would be so proportioned that

a train stopping in section 2T would not have exceeded an average speed of 40 m.p.h. in section 1T.

The circuits for the westbound track are arranged the same as the circuits just described.

Drawing TM6A8 shows circuits for single track arranged as described above except that an interlocking relay is used for relays EXR and WXR. This arrangement requires two time element relays at a single track crossing but we believe that the simplicity of the circuits and the flexibility of train movements compensate for what could be saved by arranging the necessary selection to use one time element relay.

Circuits TE6A1 and TE6A2:

The circuits shown on these drawings provide two timing sections for each approach. This is an expansion of the system just described to provide for two operations of the time element relay as a train approaches the crossing. The system may be further expanded to provide as many operations of the time element relay as may be necessary.

Let us explain the operation of the circuit first by assuming an eastbound train approaching the crossing at a uniform speed of 25 m.p.h. or 36.6 feet per second. Relay 1TR is shunted and completes the first pick-up circuit of relay ESR through the back contacts of relays 1TR and 3SR, front contacts of relay 2TPR, 2TR, 3TR and 4TR and the checking contact of time element relay ETER to the winding of relay ESR. Relay ESR picks up and closes a shunt around the checking contact of relay ETER and also closes the operating circuit of relay ETER.

Assume the pick-up time of relay ETER to be 15 seconds. When the train has traveled 549 feet (15 x 36.6) in the 1170 ft. section 1T, relay ETER closes its front contacts picking up relay ETEPSR. Note that relay EXR has a first circuit from battery over front contacts of relays 2TR, 2TPR, 3TR and 4TR. Also note that there is now battery over the front contacts of relays ESR and ETEPSR in multiple, then over a front contact of 4TR to energize relay EXR.

When the train shunts relay 2TR, the circuit for relay ESR is opened for a time equal to the release period of relay 2TPR which is sufficient to insure the release of relay ESR. Relay ETER is de-energized and releases. Relay ETEPSR is de-energized but is slow-releasing and is immediately re-energized by a stick circuit which includes a front contact of relay 2TPR, a back contact of relay 2TR and front contacts of 3TR and 4TR.

Relay 2TPR is also de-energized upon the release of 2TR and is also slow-releasing. It will be seen that at this time relays 2TPR and ETEPSR release in sequence and the total slow-release time of these relays can be enough to permit relay ETER to close its checking contact and for relay ESR to pick up again. This pick-up circuit for relay ESR is over front contacts of relays ETEPSR and 3TR, back contacts of relays 2TPR and 2TR, front contacts of relays 3TR and 4TR and the checking contact of ETER to relay ESR. Relay ESR up then provides battery over one of its front contacts for this circuit until relay 3TR is shunted. The circuit of time element relay ETER is again closed.

Relay EXR is now energized over front contacts of ESR and

4TR and was held energized during the above operation by battery over front contacts of relays ETEPSR and 4TR. Relay ETEPSR releases soon after ESR picks up.

A slow-pick-up relay 3SR is provided so that an interruption of the circuit of relay 3TR will not complete a second stick circuit for relay ETEPSR while a train is approaching in section 1T. Relay 3SR is picked up over back contacts on relays 2TPR and 2TR and a front contact of relay 3TR and is retained over a back contact of 3TR. The slow-pick-up feature of relay 3SR provides time for relay ETEPSR to release after relay 2TPR opens its front contacts thus insuring that the warning time will not be unduly shortened by an interruption of relay 3TR.

Referring now to the train which has just entered section 2T and re-energized relays ESR and ETER. When this train has passed into section 2T, 549 feet (15 sec. at 25 m.p.h.) time element relay ETER again closes its front contacts and again picks up relay ETEPSR. The second circuit for relay EXR is re-closed.

The train then passes into section 3T, shunting relay 3TR. Relay ETEPSR is now retained by a stick circuit over a front contact on relay 3SR, a back contact of relay 3TR and front contacts of 4TR and ETEPSR. This condition exists until the train shunts relay 4TR which opens the circuit for relay EXR. Crossing signal circuits are now closed at back contacts of relay EXR and the warning is displayed for the full time the train is in section 4T.

Also, note that the shunting of relay 3TR opens the circuit of relay ESR which in turn opens the circuit of ETER and the shunting of relay 4TR opens the circuit of relay ETEPSR. When the

train clears the crossing, relay EXR again picks up and the system is restored to normal.

Let us now assume a train traveling in section 1T at 40 m.p.h. or 59 ft. per second. In the 15 seconds required for relay ETER to pick up, this train will travel 885 ft. It is then evident that relay ETER will complete its pick up and energize relay ETEPSR before the train enters section 2T. However, the time required for the front of this train to travel through section 2T (686 ft.) is evidently less than 15 sec. which means that relay ETER would not complete its second operation and that the shunting of relay 3TR will open the circuit of relay ESR before relay ETEPSR picks up. The effect is that relay EXR releases as soon as this train enters section 3T and the crossing signal operates while the train is in sections 3T and 4T.

Now, assuming a faster train, say 70 m.p.h., entering section 1T. This train will travel 1530 ft. (15 x 102) in the pick-up time of time element relay ETER but section 1T is only 1170 ft. Section 2T will be entered before time element relay ETER completes its pick-up and relays ESR and EXR will be released. The crossing signal then operates while this train is in sections 2T, 3T and 4T.

The length of track sections shown has been calculated on the basis of a 15-second time element relay but may be modified to meet various conditions.

Note that a train, operating at less than the speed limit in sections 1T and 2T, may stop at a station in these sections or in 3T or may do switching without operating the crossing signals. Also, a train may enter sections 1T and 2T and reverse out without affecting

the crossing signals. When station stops or switching moves are to be made nearer the crossing, special means would be provided to prevent unnecessary warning.

The foregoing description applies to the double track arrangement shown on drawing TE6A1 and to the single track arrangement on TE6A2.

W. W. Gadwallader
7/1/36

TM6A3 = Motor driven "wind-up" DO 32890-A27
schema - $2300 extra cost over std layout
(includes connection for acceleration) 1/3/40

TM6A9 = Modified to simplify TM6A3 and abandon
acceleration connection.
*$662 extra cost. 1/3/40.

1250

Union Switch & Signal Co.

COPY FOR U.D. 216

EPC

Alton Railroad
Highway Crossing
Uniform Control

Swissvale, Pa., March 27, 1945

Chicago Office:

With reference to your 'WHH' letter of March 21, above subject, attached is one print each of typical circuit plans TM6A7 and A8 which include a series track relay in each timing track section. The purpose of the series relay is to prevent operation of the time control until such time as a vehicle occupies the timing section and energizes the series relay. A broken rail that would de-energize the track relay and otherwise prematurely operate the timing relay has no such effect when the series relay is employed. We believe this covers the situation that you have in mind.

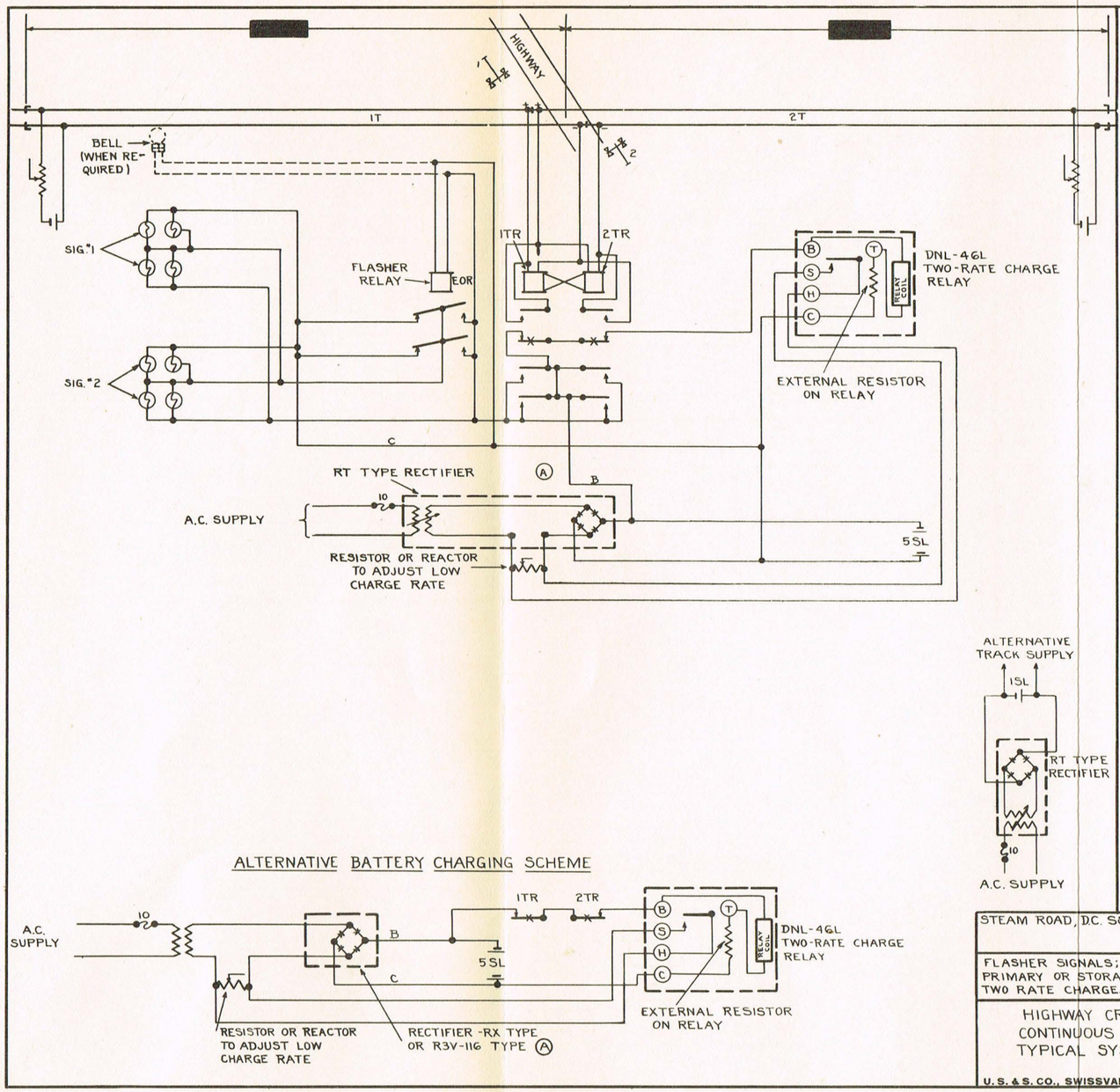
COPY

Signed H. S. Loomis

By C. W. Bell

cwb/em

cc-U.D. 216



ALTERNATIVE BATTERY CHARGING SCHEME

PRINCIPAL FEATURES

1 - LIGHTING FROM BATTERY AT ALL TIMES.

2 - DNL-46L TWO-RATE CHARGE RELAY RELEASED WHEN TRAIN ENTERS APPROACH SECTION.

3 - HIGH CHARGE RATE TO BE $\frac{1}{2}$ TO $\frac{2}{3}$ OF THE TOTAL MAXIMUM DEMAND.

4 - THE MAIN FIGURE SHOWS BATTERY CHARGED BY RT TYPE RECTIFIER AND THE ALTERNATIVE SHOWS BATTERY CHARGING BY AN RX RECTIFIER OR AN R3V-116 RECTIFIER

NOTES

(A) R3V-116 RECTIFIER MAY BE USED ONLY WHERE STEADY A.C. VOLTAGE IS AVAILABLE. WHEN THE R3V-116 RECTIFIER IS USED A SEPARATE TRANSFORMER IS REQUIRED.

REVISIONS

2	5-5-39

SYMBOL FOR DNL-46 RELAY CHANGED. TRANSFERRED ANT. INKED.

H.S.Y. 5/5/39

REFERENCES

STEAM ROAD, D.C. SCHEME,

FLASHER SIGNALS; POWER, STORAGE FOR SIGNALS, PRIMARY OR STORAGE FOR TRACK, TWO RATE CHARGE.

HIGHWAY CROSSING SYSTEM
CONTINUOUS CONTROL TYPE
TYPICAL SYSTEM CIRCUITS

U.S. & S. CO., SWISSVALE, PA. SCALE:

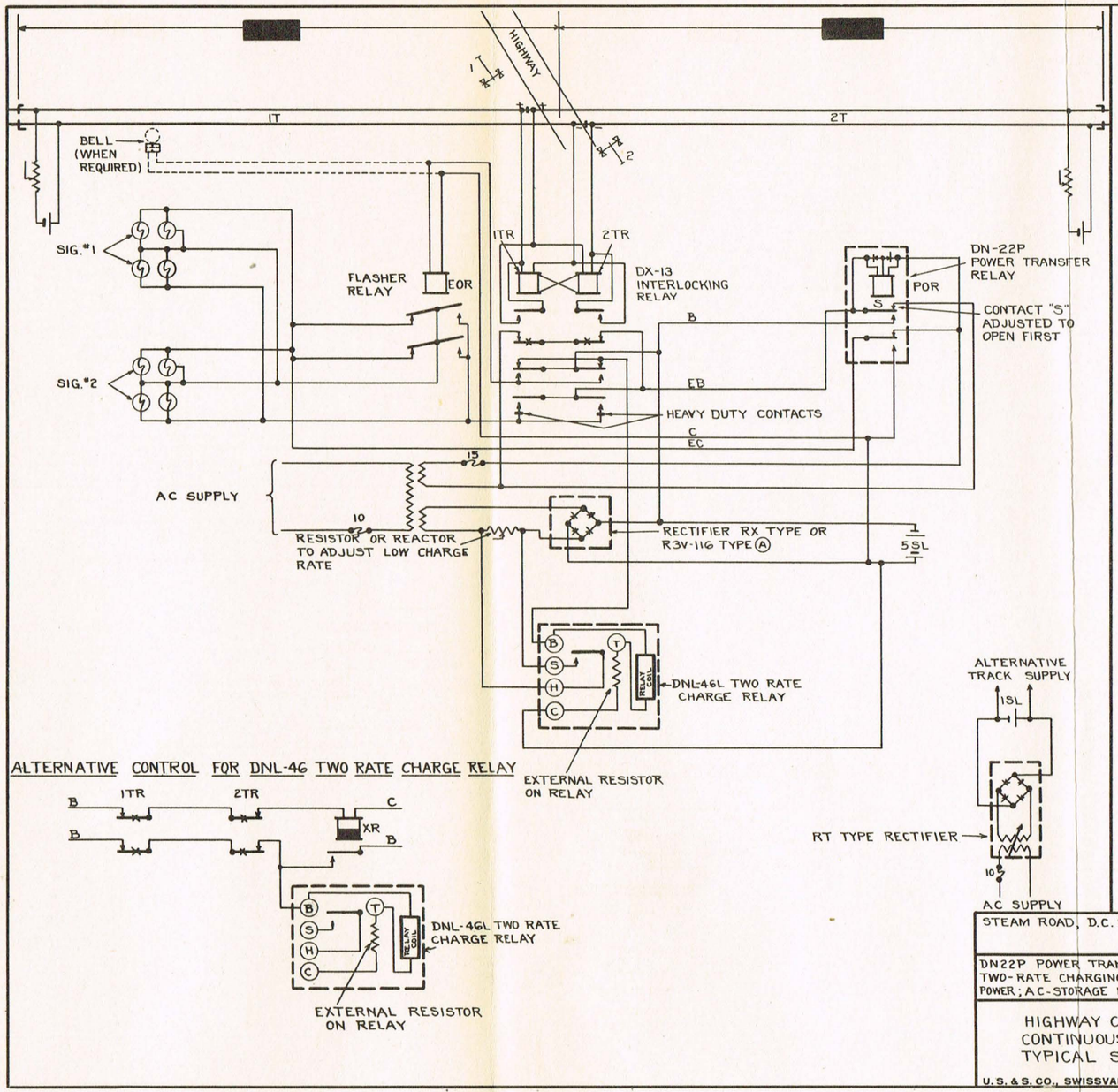
DESIGNED H.S.Y.
DRAWN JRH-BB
TRACED JRH
CHECKED
OK'D

APPROVED H.S.Y. DATE 11-2-38

SHEETS SHEET NO. 1

DATE 10-11-38

TB8A28



PRINCIPAL FEATURES

1 - LAMPS NORMALLY FED FROM AC AND TRANSFERRED TO BATTERY UPON LOSS OF AC POWER OR UPON REDUCTION OF AC VOLTAGE TO 70% OF POR NORMAL RATING.

2 - STICK CIRCUIT OF POR USED TO PREVENT INTERMITTENT OPENING AND CLOSING OF THE CONTACTS UNDER LOAD IN EVENT OF VOLTAGE FLUCTUATIONS.

3 - THE DNL-46L TWO RATE CHARGE RELAY IS RELEASED WHEN A TRAIN SPANS THE CROSSING. IF THE TWO RATE CHARGE RELAY WERE RELEASED DURING THE FULL TIME AN APPROACH IS OCCUPIED THE BATTERY WOULD BE OVERCHARGED.

4 - AN ALTERNATIVE SCHEME IS SHOWN FOR RELEASING THE DNL-46L TWO RATE CHARGE RELAY WHEN A TRAIN ENTERS AN APPROACH WHEN AN XR RELAY IS USED.

5 - WHERE LOCAL OPERATING CONDITIONS ARE SUCH THAT THERE IS A POSSIBILITY OF BOTH TRACK CIRCUITS BEING OCCUPIED FOR RELATIVELY LONG PERIODS OR WHERE CIRCUIT CONDITIONS REQUIRE AN XR RELAY, USE THE ALTERNATIVE SCHEME FOR RELEASE OF DNL-46L RELAY

NOTES

(A) THE R3V-116 RECTIFIER TO BE USED ONLY WHERE STEADY AC VOLTAGE IS AVAILABLE

REVISIONS

6	5-5-39

SYMBOL FOR DNL-46 RELAY CHANGED. TRANSFERRED AND INKED.

GMO RBy

REFERENCES

STEAM ROAD, D.C. SCHEME,

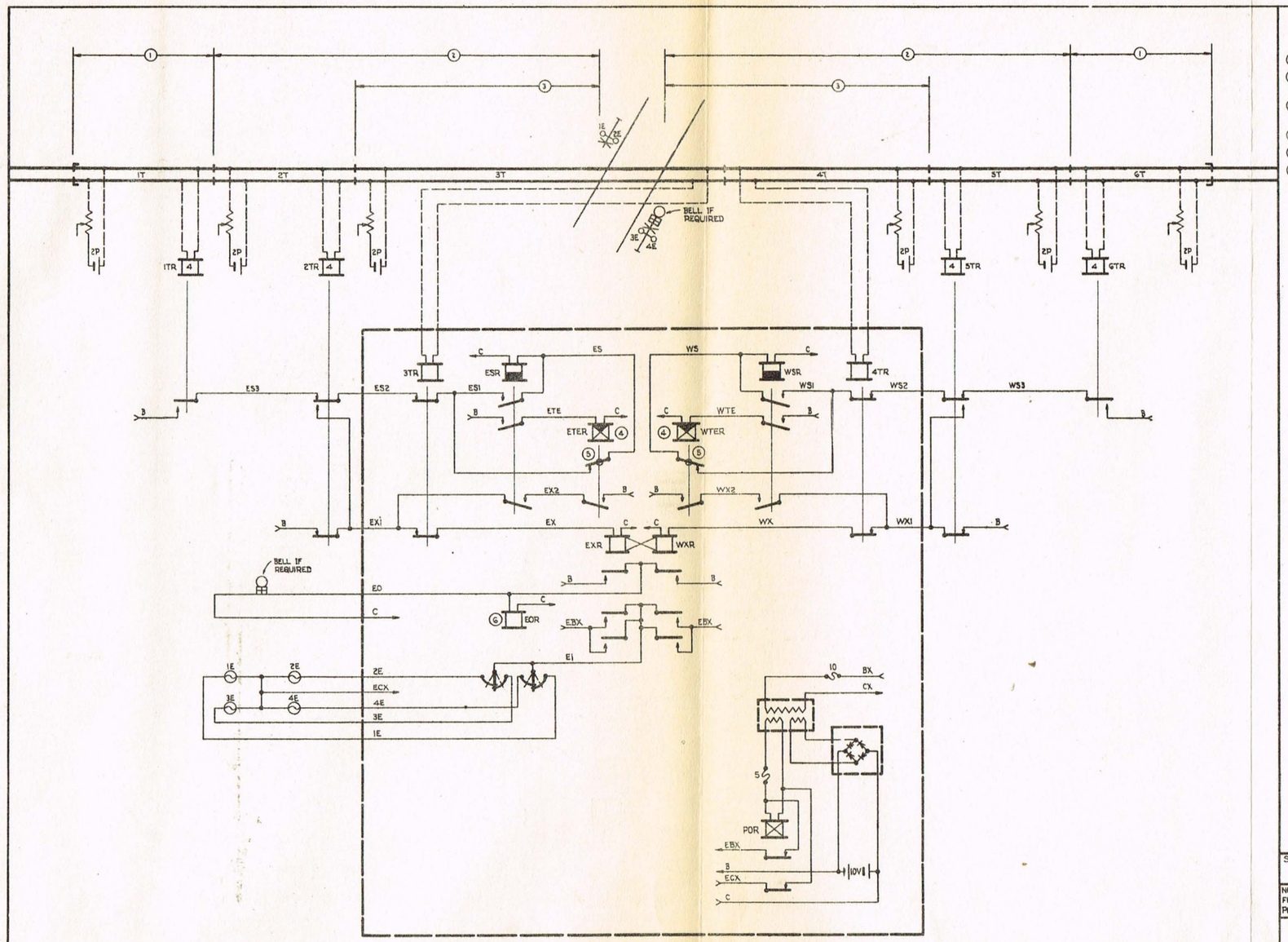
DN22P POWER TRANSFER RELAY, TWO-RATE CHARGING, FLASHER SIGNALS, POWER; AC-STORAGE FOR SIGNALS, PRIMARY OR STORAGE FOR TRACK.

HIGHWAY CROSSING SYSTEM
CONTINUOUS-CONTROL TYPE
TYPICAL SYSTEM CIRCUITS

U.S. & S. CO., SWISSVALE, PA. SCALE:

DESIGNED	JJV
DRAWN	EWL
TRACED	FISHER
CHECKED	JJV
OK'D	
APPROVED	HSY
DATE	10-23-34
SHEETS	1
SHEET NO.	1
DATE	10-11-34

TB8A18



NOTES

1. APPROACH-TIMING SECTION
2. DISTANCE TO BE SUFFICIENT TO GIVE ADEQUATE WARNING FOR HIGH SPEED TRAIN
3. TRAIN APPROACHING CROSSING ON THIS SECTION WILL OPERATE SIGNALS REGARDLESS OF SPEED
4. TIME-ELEMENT RELAY
5. CHECKING CONTACT
6. FLASHER RELAY

REVISIONS

REFERENCES

STEAM ROAD, D.C. SCHEME,

NORMALLY DE-ENERGIZED APPROACH-STICK CIRCUIT, TWO TIME-ELEMENT RELAYS, FLASHER SIGNALS, SINGLE TRACK, POWER-PRIMARY FOR TRACK, A.C. STORAGE FOR SIGNALS.

HIGHWAY CROSSING SYSTEM
UNIFORM-CONTROL-TIME TYPE
TYPICAL SYSTEM CIRCUITS

U.S.&S. CO., SWISSVALE, PA. SCALE: NONE

DESIGNED EMA
DRAWN JTG
TRACED JTG
CHECKED
OK'D

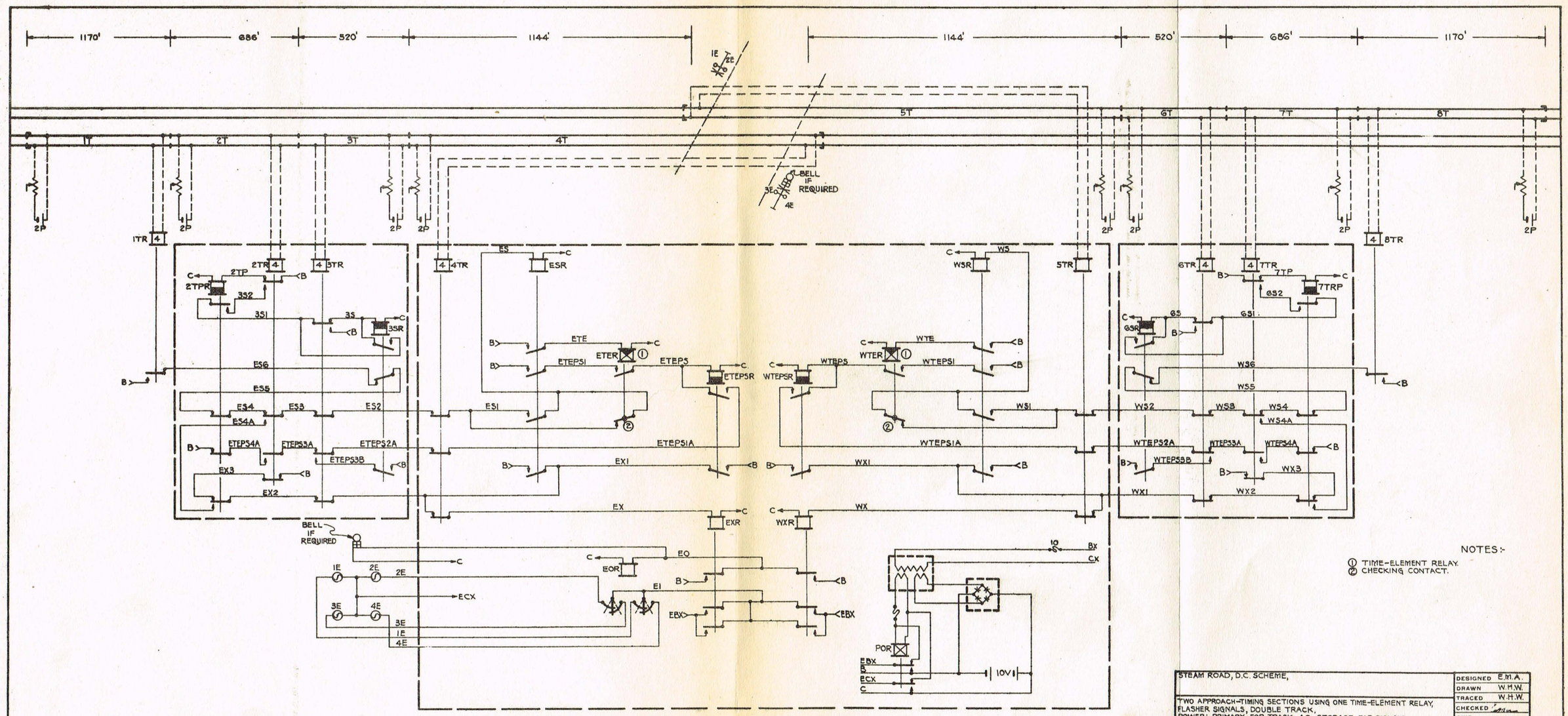
APPROVED [illegible] DATE 1-22-36

1 SHEETS SHEET NO. 1

DATE 1-22-36

TM6A8

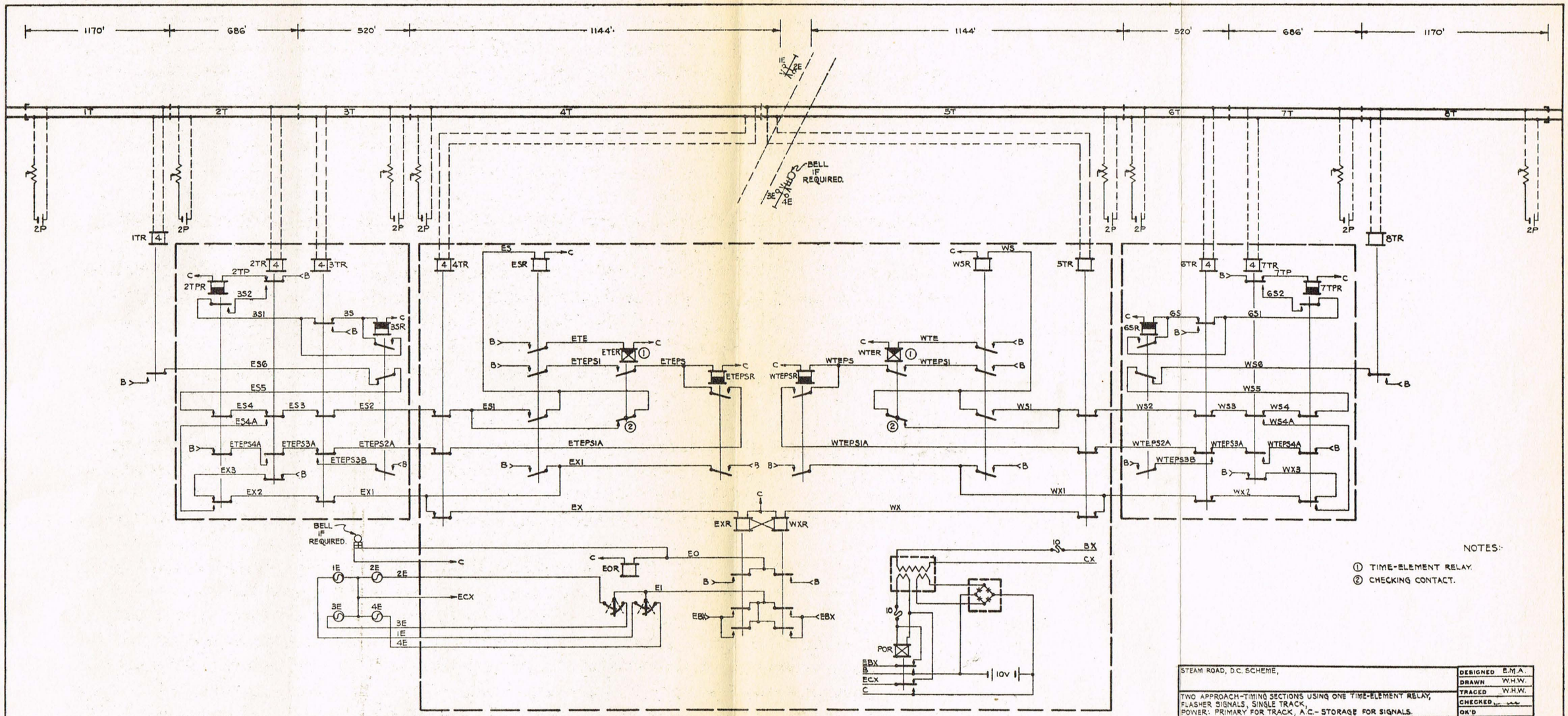
$1200 extra cost over std layout 1/2/40



NOTES:-

① TIME-ELEMENT RELAY.
② CHECKING CONTACT.

STEAM ROAD, D.C. SCHEME,	DESIGNED E.M.A.
	DRAWN W.H.W.
TWO APPROACH-TIMING SECTIONS USING ONE TIME-ELEMENT RELAY, FLASHER SIGNALS, DOUBLE TRACK, POWER: PRIMARY FOR TRACK, A.C.-STORAGE FOR SIGNALS.	TRACED W.H.W.
	CHECKED
	O.K'D
HIGHWAY CROSSING SYSTEM UNIFORM-CONTROL-TIME TYPE TYPICAL SYSTEM CIRCUITS	APPROVED DATE 1-25-36
	1 SHEETS SHEET NO. 1
U.S.&S.CO., SWISSVALE, PA. SCALE: NONE	DATE 1-21-36 TE6AI

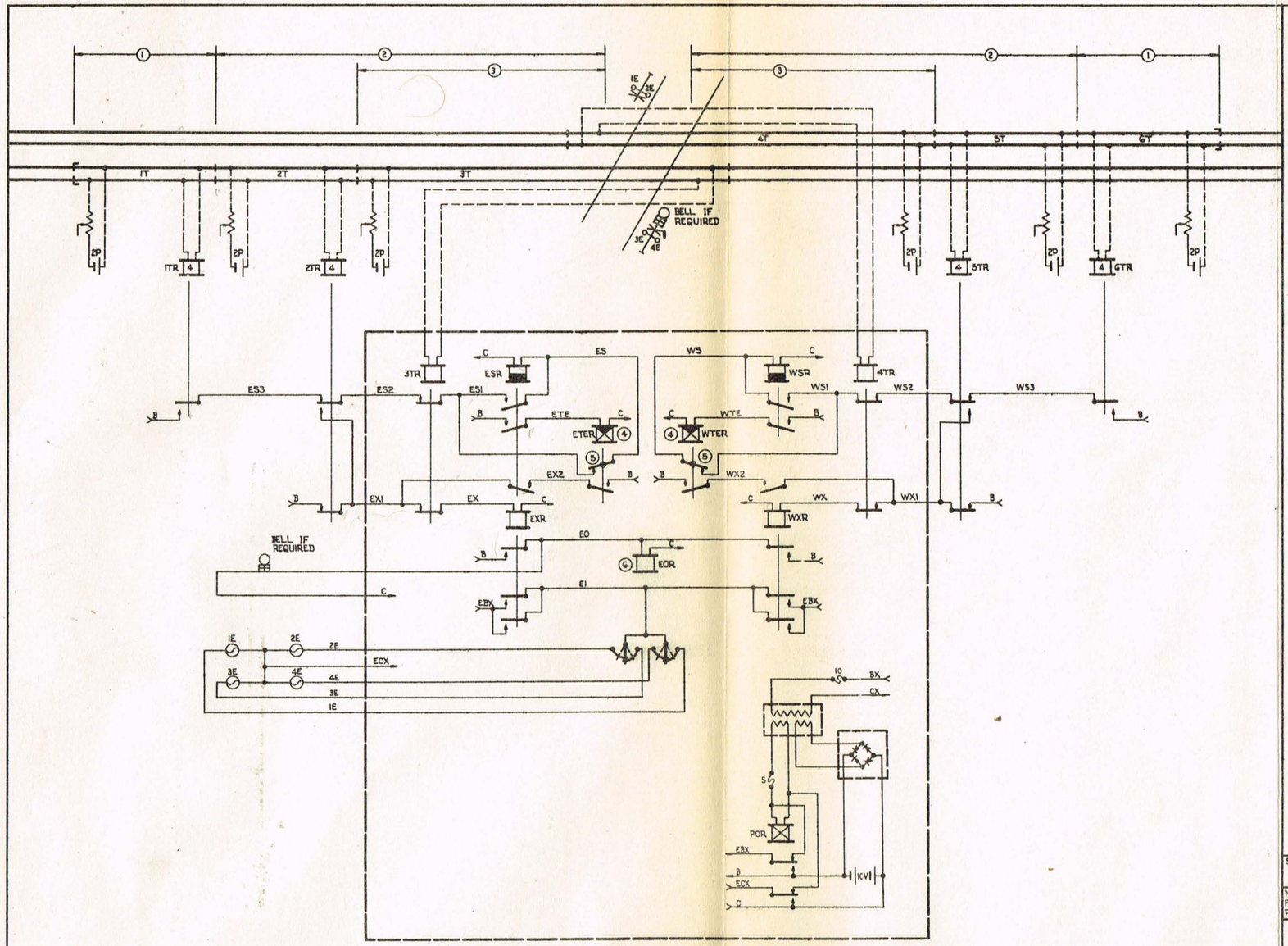


NOTES:

① TIME-ELEMENT RELAY.
② CHECKING CONTACT.

STEAM ROAD, D.C. SCHEME,	DESIGNED E.M.A.
	DRAWN W.H.W.
TWO APPROACH-TIMING SECTIONS USING ONE TIME-ELEMENT RELAY, FLASHER SIGNALS, SINGLE TRACK, POWER: PRIMARY FOR TRACK, A.C.-STORAGE FOR SIGNALS.	TRACED W.H.W.
	CHECKED
	O.K'D
HIGHWAY CROSSING SYSTEM UNIFORM-CONTROL-TIME TYPE TYPICAL SYSTEM CIRCUITS	APPROVED / DATE 1-23-36
U. S. A. S. CO., SWISSVALE, PA. SCALE: NONE	1 SHEETS SHEET NO. 1
	DATE 1-22-36 TE6A2

$2100 extra cost over std layout
1/21/40



NOTES

1. APPROACH-TIMING SECTION
2. DISTANCE TO BE SUFFICIENT TO GIVE ADEQUATE WARNING FOR HIGH SPEED TRAIN
3. TRAIN APPROACHING CROSSING ON THIS SECTION WILL OPERATE WARNING SIGNALS REGARDLESS OF SPEED
4. TIME-ELEMENT RELAY
5. CHECKING CONTACT
6. FLASHER RELAY

REVISIONS

REFERENCES:
DOCKET.....3510

STEAM ROAD, D.C. SCHEME,

NORMALLY DE-ENERGIZED APPROACH-STICK CIRCUIT,
FLASHER SIGNALS, DOUBLE TRACK,
POWER: PRIMARY FOR TRACK, A.C. STORAGE FOR SIGNALS.

HIGHWAY CROSSING SYSTEM
UNIFORM-CONTROL-TIME TYPE
TYPICAL SYSTEM CIRCUITS

U.S. & S. CO., SWISSVALE, PA. SCALE: NONE

DESIGNED E.M.A.
DRAWN J.T.G.
TRACED J.T.G.
CHECKED
O.K'D
APPROVED
DATE 1-22-36
1 SHEETS SHEET NO. 1
DATE 1-21-36

TM6A7